SPRING MIGRATION OF WATERFOWL IN THE YELLOWKNIFE - THOR LAKE AREA NORTHWEST TERRITORIES: 1986

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Jacques Sirois
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ABSTRACT

A survey of migrating waterfowl was conducted, from 10 May to 02 June 1986, in the area of the Thor Lake Mine development. Other staging sites in the intervening area between the mine development and Yellowknife were also surveyed. Objectives of the study were: 1) to document the waterfowl species which occur in the area, 2) to determine the distribution (spatial and temporal) and abundance of waterfowl species in the area and 3) to evaluate the Thor Lake Mine site, in a regional context, with regard to migrating waterfowl.

A total of 32 species, including 26 waterfowl species, were observed; most birds were concentrated in areas of open water. Open water areas occurred in shallow sheltered bays and along creek and river systems. The greatest concentration and variety of waterfowl were observed along the Beaulieu River. Migration in the Yellowknife - Thor Lake area peaked between 14 - 20 May.

A total of 17 species, including 14 waterfowl species, were observed on the Thor Lake study site. Numbers of most species had declined significantly by the end of the study period. This survey did not reveal any significant migratory bird populations near the mine site. Accordingly, the mine development should not result in any significant negative impacts. Additional surveys would further substantiate this conclusion.

RÉSUMÉ

Des inventaires aériens d'oiseaux aquatiques ont été menés entre le 10 mai et le 2 juin 1986 dans la région du lac Thor, où un projet de développement minier est à l'étude. Ces inventaires nous ont permis de survoler plusieurs sites d'arrêt migratoire utilisés par les oiseaux entre Yellowknife et le site de la future mine. Nous avions pour objectifs: 1) d'identifier les espèces d'oiseaux aquatiques présentes dans la région, 2) de déterminer leurs distributions spatiale et temporelle, et 3) d'évaluer l'importance régionale du site de la mine en ce qui regarde la migration de la sauvagine.

Un total de 32 espèces d'oiseaux, dont 26 de sauvagine, ont été observées. Les oiseaux étaient concentrés dans le fond des baies peu profondes et le long des cours d'eau, là où la glace avait déjà fondu. C'est sur la rivière Beaulieu que la plus grande concentration et diversité d'oiseaux ont été observées. La migration a atteint son point culminant entre le 14 et le 20 mai.

Un total de 17 espèces d'oiseaux, dont 14 de sauvagine, ont été observées dans les environs du lac Thor. Nous avons noté que pour la plupart des espèces, le nombre d'individus observé a décliné de façon remarquable vers la fin de la période d'observation. Ces inventaires n'ont révélé aucune population d'oiseaux d'importance dans la région du lac Thor. Ainsi tout projet de développement minier dans cette région ne devrait pas avoir d'impact significatif sur les populations d'oiseaux migrateurs.

Seuls des inventaires additionnels nous permettront de confirmer cette conclusion.

ACKNOWLEDGEMENTS

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Susan Popowich and Denis Valiquette prepared the figures.

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1.0 INTRODUCTION

1.1 Thor Lake Mine Development

The Thor Lake area (62° 06' N, 112° 35' W, Fig. 1) was first staked in 1970 and restaked in 1976 by Highwood Resources of Calgary. Exploratory diamond drilling, conducted from 1977 to 1981, identified deposits, in the order of 70 million tonnes containing niobium, tantalum, zirconium, and other rare-earth elements. Subsequent sampling, in 1983 and 1984, confirmed the existence of beryllium deposits in excess of 1.6 million tonnes.

Sampling and metallurgical testing are continuing and a mine feasibility study is in preparation. The company plans to initially mine 900 tonnes per day, yielding approximately 225 tonnes of ore concentrate. The dried ore concentrate will be shipped from the mine site via winter road or boat.

Present site developments associated with the Thor Lake Beryllium Project include accommodation for personnel and a short winter road which terminates at Hearne Channel (Fig. 2). Further developments will be subject to the results of the feasibility study.

1.2 Potential Environmental Impacts

Mining activities may result in two main types of impact on migratory birds: the degradation of their habitats, and disturbance. After extraction, ore is refined and concentrated. Although the concentrator is usually confined to the mill plant, the concentration process often involves leaching with highly

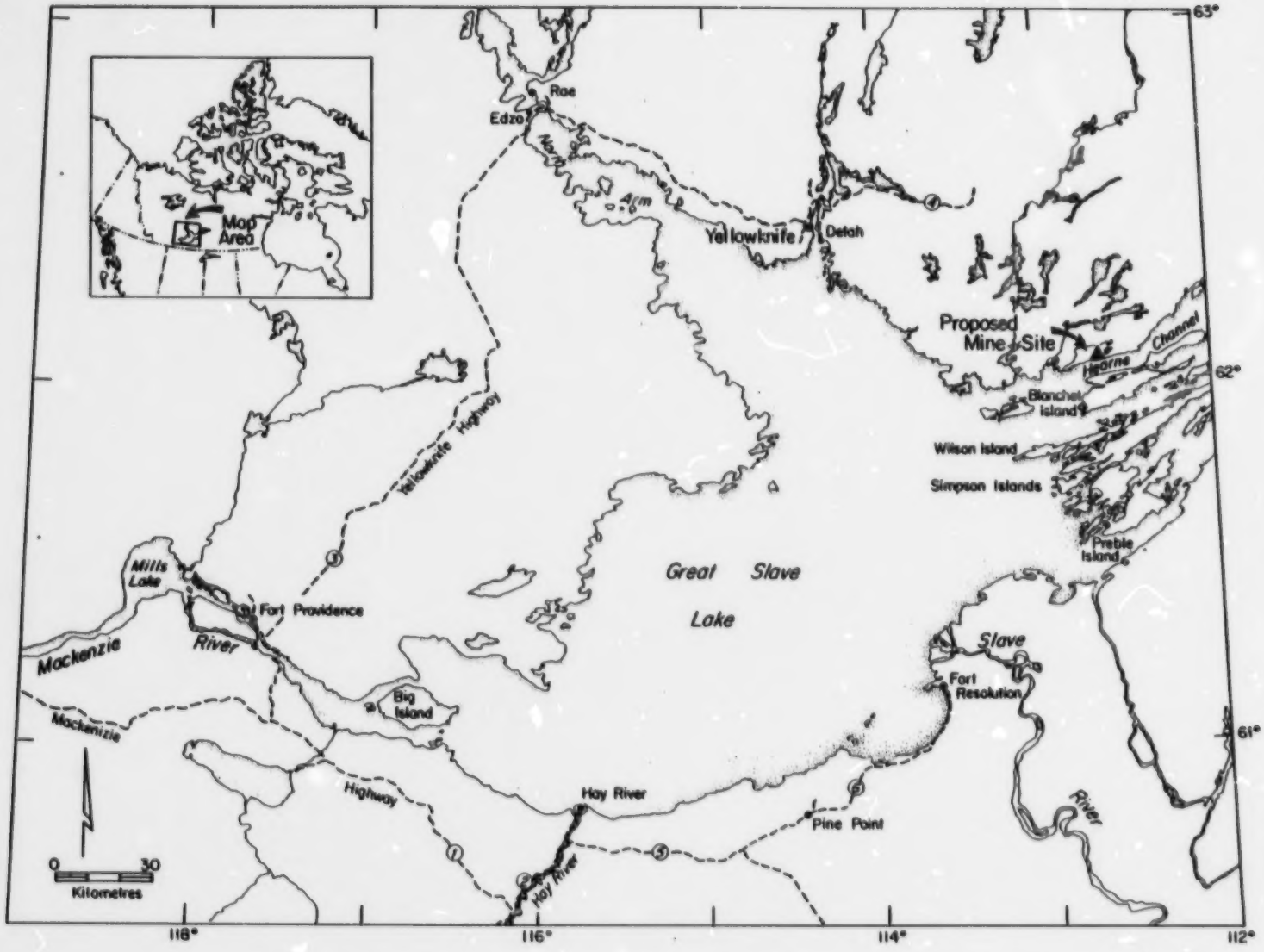

Figure 1. Location of the proposed Thor Lake Mine site within Northwest Territories.

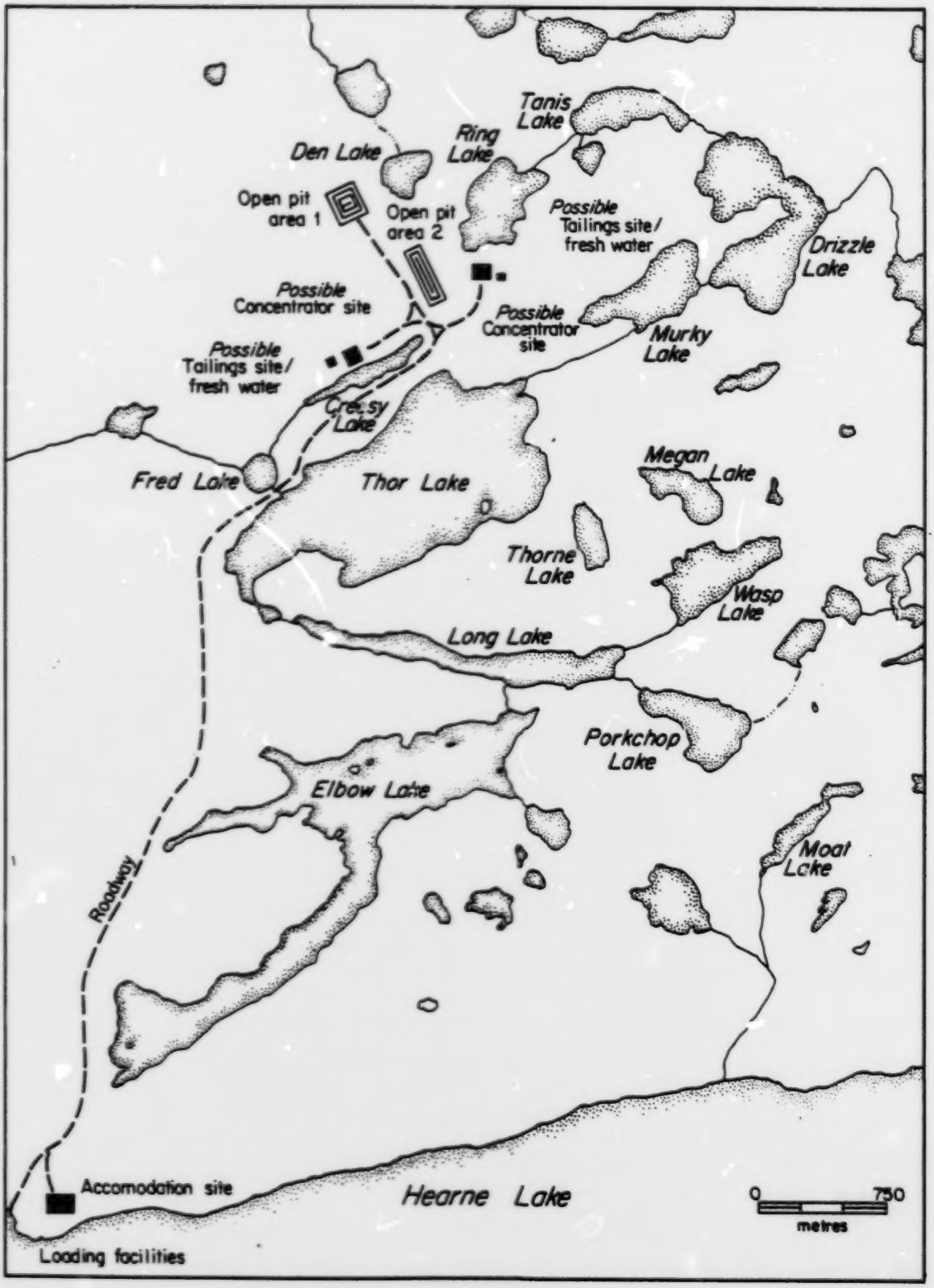

Figure 2. Present and proposed developments at Thor Lake Mine site.

concentrated acids or alkalis which are discarded into a tailings pond. The uncontrolled release of tailings into adjacent water systems could result in significant negative impacts to waterbirds and their habitats. Such impacts would be mediated through the disruption of the food chains, the elimination of protective plant cover, or ultimately the death of the birds due to toxic compounds.

Construction activities, aircraft traffic, and human activity may result in disturbance to wildlife. The impact of disturbance is a function of the species involved, the number of individuals present, the phase of their annual cycle and the availability of comparable habitat nearby. Species which congregate in a particular area or in specific habitats are most vulnerable to site-specific impacts. Such species include migrating waterfowl, colonial breeding birds, such as gulls, and breeding raptors.

1.3 Study Objectives

This study was undertaken in light of the above-mentioned potential impacts. Ideally, an evaluation of the avifauna on the study site would include both aerial surveys and ground studies for three to five seasons prior to project initiation. Although a previous study at nearby Bullmoose Lake (Arner and Verreault 1985) provides some insight into the breeding birds of the area, additional work, on staging species, will provide a better perspective on the importance of this area to migratory waterbirds.

Aerial surveys were undertaken to:

1) document the waterfowl species which occur in the area;
2) determine the temporal and spatial distribution and abundance of waterfowl species in the area;
3) evaluate the importance of the study site, in a regional context, to migrating waterfowl.

2.0 STUDY AREA

Thor Lake (62° 06' N, 112° 35' W) is situated approximately 105 km southeast of Yellowknife, and is adjacent to Hearne Channel, Great Slave Lake (Fig. 1). The study area includes all sites of open water between Yellowknife and the Thor Lake site (Fig. 3). The study site includes Thor Lake, Elbow Lake, and all other waterbodies within approximately five km of the proposed mine location (Fig. 3).

2.1 Climate

Although there are no climatic data from the Thor Lake site, certain inferences can be drawn from Yellowknife records. This area experiences a continental climate with short, warm summers and long, cold winters. The mean daily temperature in January is -29° C and in July is 16° C (Atmos. Env. Serv. 1982). Mean daily temperatures at Yellowknife are above freezing from May to September. They are summarized for the duration of the 1986 spring break-up in Figure 4. The mean daily temperatures during spring break-up, between 1943 and 1984, are also depicted.

Freeze-up begins on the smaller ponds by early October and

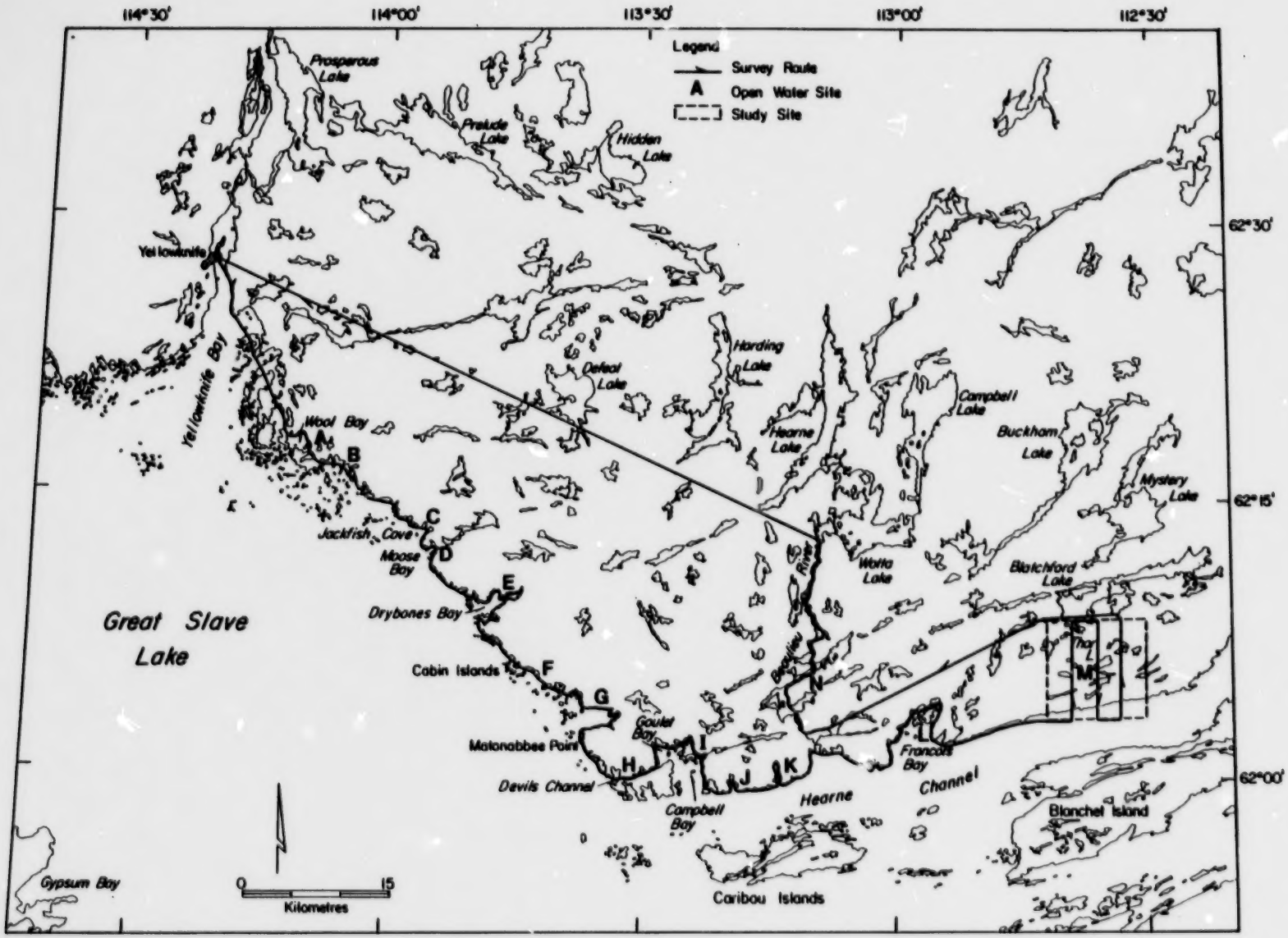

Figure 3. Location of open-water sites in the Yellowknife-Thor Lake area, Spring 1986.

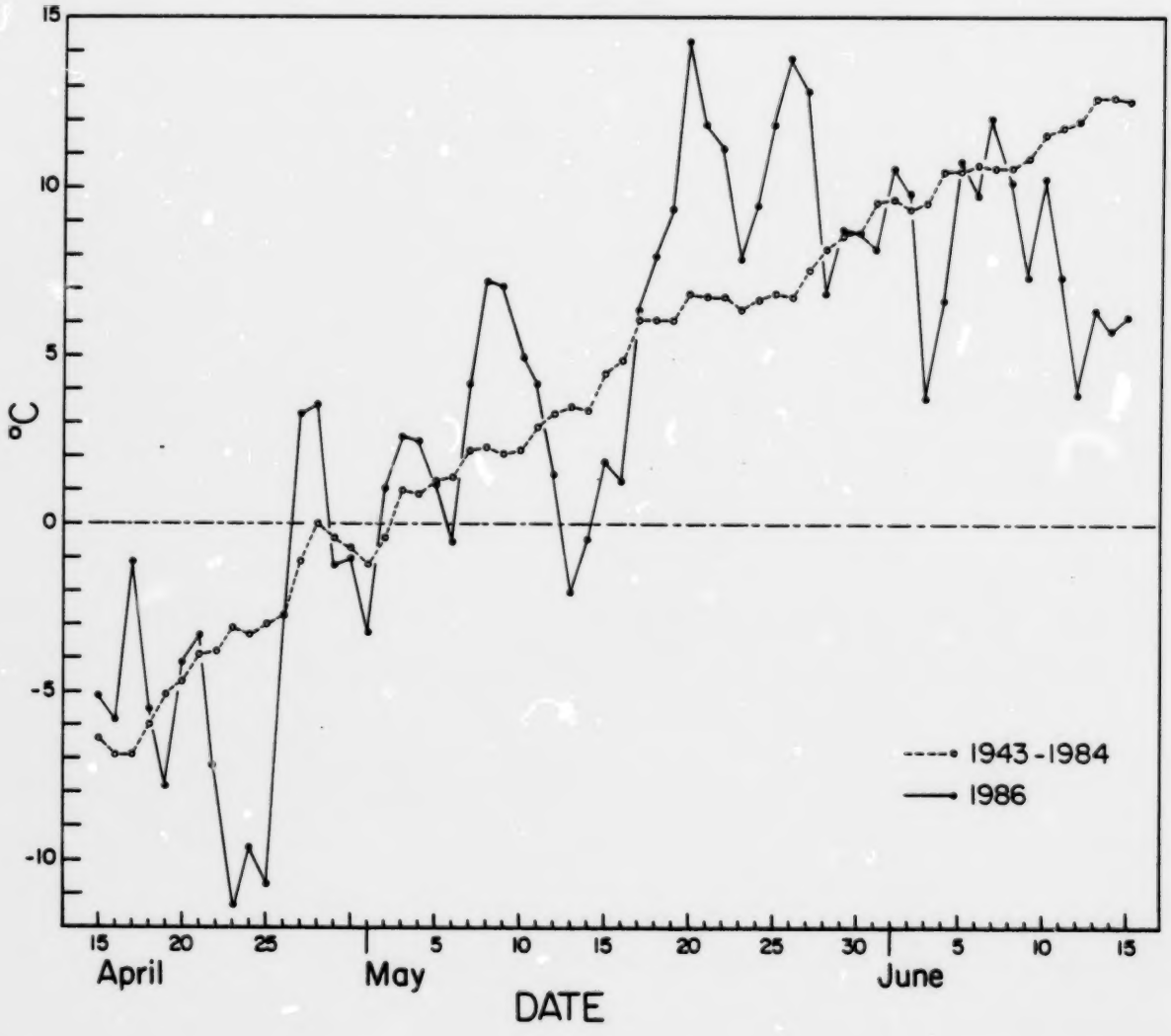

Figure 4. Main daily temperatures during spring break-up at Yellowknife, 1986.

continues on the larger lakes and rivers into November. Small waterbodies are usually open by mid-May and larger lakes are open by early June. The progression of ice melt in Hearne Channel, during 1986 (Table 1), suggested that temperatures are colder in the vicinity of the mine site than at Yellowknife.

2.2 Physiography

The study area lies within the Bear-Slave Uplands physiographic region of the Precambrian Shield. Numerous lakes, marshes, bogs, and watercourses fill the hollows, and rounded rocky hills of less than 100 metres in height characterize the region (Bostock 1970).

The study site is characteristically flat and rises abruptly (approximately 60 to 65 metres) from the nearby Hearne Channel. It is dominated by numerous lakes and ponds which appear to be stagnant. Although no permanent drainage system is obvious, intermittent streams do connect a number of the waterbodies. Exposed bedrock comprises approximately 10% of the site.

2.3 Vegetation

The site is dominated by open boreal forest often referred to as subarctic open lichen-woodland or northwestern transition zone (Rowe 1972). The tree line lies less than 200 km to the northeast. The landscape is characterized by dry uplands and wet lowlands. Major plant communities include jackpine uplands, birch-aspen slopes, spruce bogs, shrubby stream valleys, shorelines of shrubs and emergents, and submerged aquatics. These

Table 1. Ice conditions in the Yellowknife - Thor Lake area, Spring 1986.

Date	Yellowknife Bay to Campbell Bay	Thor Lake - Hearne Channel	Comments
10 May	small ponds open; some lakes with leads 1-10 m wide; some open water in protected bays of GSL*.	a few shallow ponds open; snow cover ±15%; Hearne Channel all ice-covered	Francois and Beaulieu rivers and Devil's Channel already open.
14 May	Shoreleads in GSL are 5-20 m in some areas. Many lakes with no shoreleads.	About 10 shallow ponds are open.	Much wet snow in open waters due to heavy snow the previous day.
17 May	Shoreleads in GSL are 10-20 m wide in some areas; extending to 100m in one location.	5% snow cover; evidence of meltwater in Hearne Channel.	Solid ice in bigger bays of GSL.
20 May	Shoreleads 30 m wide in some areas. Small islands encircled by water.	All ponds and many lakes open. Leads in Francois Bay and Hearne Channel are 10 m wide.	Most small bays of GSL are open.
23 May	Shoreleads up to 100 m in many areas.	Virtually all waterbodies open. Hearne Channel has leads 15-20 m wide. Thor Lake has rotten ice.	Rotten but contiguous ice on GSL. All small bays of GSL are open.
26 May	Shoreleads at least 20 m wide everywhere; many areas of open water have coalesced.	Most waterbodies are ice-free.	Most large bays of GSL are completey open.

Table 1. Continued.

Date	Yellowknife Bay to Campbell Bay	Thor Lake - Hearne Channel	Comments
29 May	Leads 100-200 m wide	All waterbodies, but Hearne channel, are ice-free.	Large bays entirely open.
02 June	Shoreleads continue to expand.	Solid ice still in Hearne Channel with leads 10-20 m along the north shore.	Offshore waters of GSL still ice-covered. Open water restricted to pressure ridges, shorelines and bays.

* GSL - Great Slave Lake

communities are respectively characterized by Jack Pine (Pinus banksiana), White Birch (Betula papyrifera), Black Spruce (Picea mariana), Green Alder (Alnus crispa), Sweet Gale (Myrica gale), River Horsetail (Equisetum fluviatile), and Yellow Pond-lily (Nuphar variegatum).

3.0 METHODS

Aerial surveys of the Thor Lake site and other staging locales in the study area (Fig. 3) were conducted at three-day intervals from 10 May to 02 June, 1986. The initial survey was flown in a Cessna 180 aircraft and all subsequent surveys were conducted in a Supercub. The surveys were flown at approximately 125 km/h and 25 to 30 metres above ground level. Flight speed and height were reduced, as necessary, to examine certain staging sites. Two observers were present for the initial survey; one thereafter. All observations were recorded on tape recorders and subsequently transferred onto appropriate forms.

The flight path was maintained parallel to and within 100 metres of Great Slave Lake's shoreline at all sites except Wool Bay and Thor Lake. At Wool Bay, a short creek perpendicular to the shoreline was also surveyed and at Thor Lake, a 36-km survey line, encompassing the entire study site, was flown (Fig. 3). At all sites but Thor Lake, only usable habitat or open water was surveyed. At Thor Lake, the flight path covered both land and waterbodies. The length of the surveyed open-water sites varied from three kilometres at Wool Bay to 24 km at Beaulieu River. The width of these areas increased throughout the study period as the

ice receded. No attempt was made to define a transect width, and at each site, all observed birds were recorded irrespective of their distance from the flight path.

The relative importance of the various site was determined by calculating the percent of the total observations of a particular species which was recorded at a particular site. The percentage values for each of the ten most common species or species groups were then summed to yield an "Index of Importance".

4.0 RESULTS

4.1 Abundance of Migrating Species

The abundance of species observed at each site is summarized in Appendices 2-15. Approximately 16,800 observations yielded 32 bird species, including 27 waterfowl species. As Greater and Lesser Scaup were impossible to distinguish during the survey, they were lumped as Scaup spp. Ring-necked Ducks may also have been identified as Scaup if they occurred in the same flocks. Overall, 24.8% of the total observations were of Scaup spp., followed by Tundra Swan (13.8%), Canada Goose (4.7%), American Wigeon (3.9%), Surf Scoter (3.8%), Mallard (3.7%), Northern Pintail (2.4%), Bufflehead (1.9%) and White-winged Scoter (1.3%). Bird silhouettes and behaviour suggest that most of the unidentified ducks (32.1% of all observations) were dabblers such as Mallard, Northern Pintail and American Wigeon.

Approximately 600 observations were recorded on the Thor Lake study site. Seventeen species, including 14 waterfowl species

were recorded. Scaup spp. accounted for most of the observations (47%), followed by Greater White-fronted Goose (11.8%, seen flying over the study site), Surf Scoter (8%), White-winged Scoter (6.7%), Oldsquaw (5.2%), Lesser Snow Goose (1.6%, seen flying over the study site), Bufflehead (1.5%), Red-necked Grebe (1.2%), Common Loon (1%), and American Wigeon (1%). Unidentified ducks accounted for 10.7% of the total observations.

4.2 Spatial Distribution

A total of 14 sites, including the Thor Lake study site, were surveyed. The relative importance of each site, in terms of abundance of birds, is depicted in Figure 5. The Thor Lake study site ranked ninth, as determined by an importance index based on the occurrence of the ten most common species (Table 2).

The highest numbers of birds did not necessarily occur where open water was most available (Appendix 16). The highest number (one third of all observations) was recorded on the Beaulieu River, the longest stretch of open water surveyed (24 km). Areas such as Devil's Channel and Cabin Islands had much shorter stretches of open water (6 and 7.5 km respectively) but ranked second and third, ahead of Drybones Bay which ranked eighth with a 12.5-km stretch of open water.

The number of observed species varied from 11 to 23 per site. The diversity of species was not directly correlated to the abundance of birds (Appendix 16). Seventeen species were observed on the Thor Lake study site, ranked ninth in importance, whereas 18 species were observed at Devil's Channel and 22 species

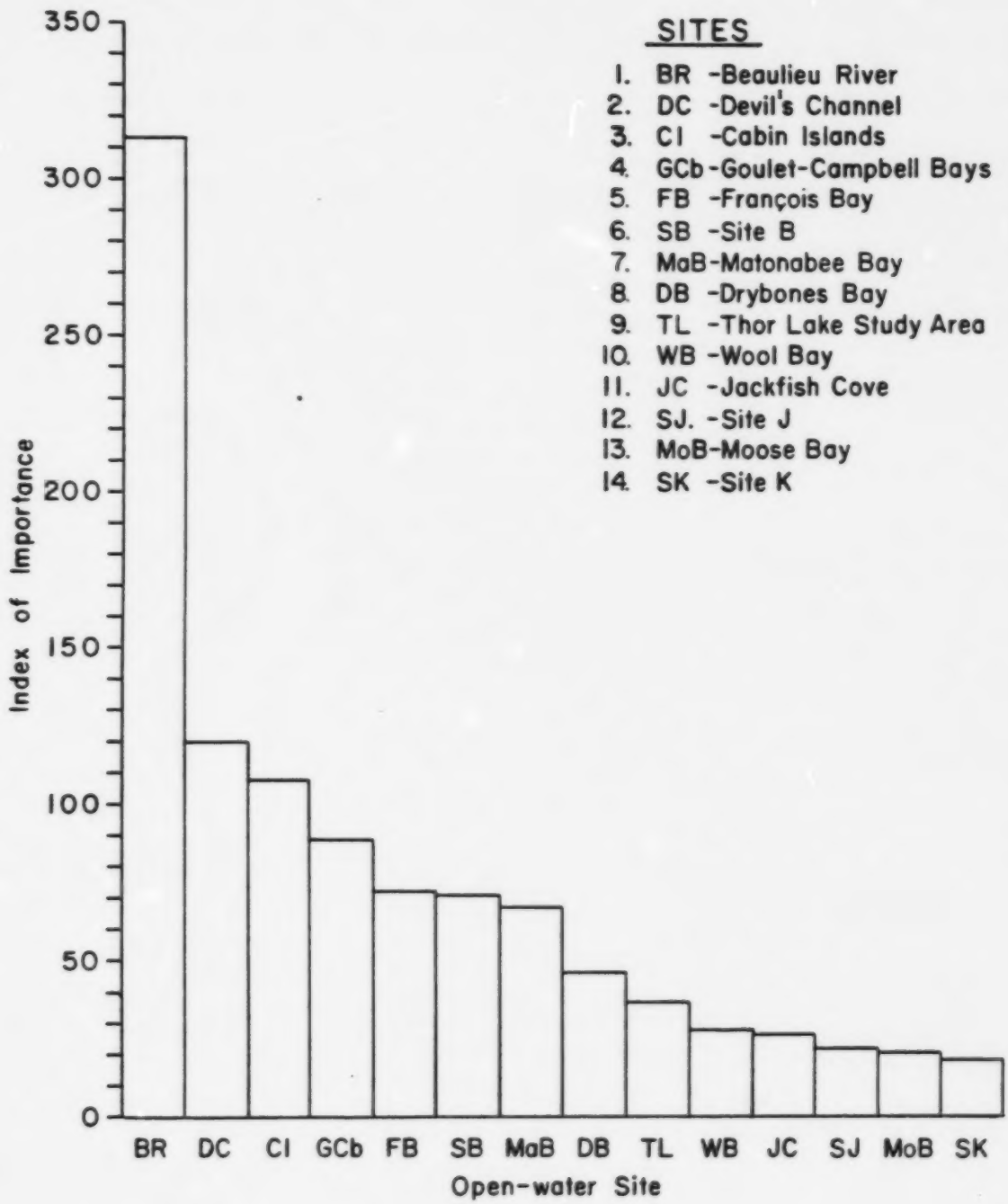

Figure 5. Relative importance of each open-water site to migrating waterfowl, Spring 1986.

Table 2. Percent abundance of the most common species at each open water site.

Site	Species										Imp. Index
	TS	CG	MA	NP	AW	SC	BU	DU	WS	SS	
Wool Bay	.08		2.54		.45	4.82	5.50	11.84	1.80		27.03
Site B	3.63		16.69	4.84	4.81	3.65	10.09	10.41		6.80	60.92
Jackfish Cove	3.84	2.09	1.74		.30	3.29	6.89	6.81			26.96
Moose Bay	2.24		7.47		.30	1.56	1.22	5.06		2.47	20.32
Drybones Bay	2.85	1.87	11.60	6.29	4.06	8.38	1.22	6.58	.45	2.31	45.61
Cabin Islands	14.65	5.48	4.92	16.22	18.80	3.96	1.52	5.14	30.76	5.40	106.85
Matonabee Bay	12.79	4.36	8.90	12.10	8.43	3.19		4.95	.45		55.17
Devil's Channel	9.81	53.60	3.33	0.48	6.92	7.70	2.44	7.55	13.57	13.60	119.00
Goulet-Campbell bays	8.69	1.87	1.58	22.51	14.30	5.88	10.70	5.19	6.78	9.73	87.23
Site J	.08		1.90		3.76	1.92	1.22	.40	11.31		20.59
Site K	.08		7.63	.48	2.10	.86	5.19	1.13	2.26		19.73
Francois Bay	11.15	.12	2.38	2.66	8.58	7.27	7.03	2.82	11.76	8.34	62.11
Thor Lake			.31		.90	6.70	2.75	1.18	18.09	7.4[illegible]	37.34
Beaulieu River	30.04	30.17	28.93	34.38	26.20	40.77	42.20	30.88	2.71	43.8[illegible]	310.17
Total number of observations	2313	802	629	413	664	4164	327	5388	221	647	

TS - Tundra Swan; CG - Canada Goose; MA - Mallard; NP - Northern Pintail; AW - American Wigeon; SC - Scaup spp.; BU - Bufflehead; DU - ducks; WS - White-winged Scoter; SS - Surf Scoter.

were recorded at Goulet-Campbell bays, ranked second and fourth respectively in importance.

4.3 Temporal Distribution

The temporal abundance of all species at the 14 sites is depicted in Table 3. Relatively few birds were seen on the first survey (10 May). A peak of migratory activity was recorded on 17 June when about 37% of all observations were made. About 65% of all observations were made during three of the eight surveys: 14, 17 and 20 May. The number of birds declined slightly after 20 May and sharply after 23 May. It remained low until the end of the study period. The migration peaks for each species indicate that Mallard, Northern Pintail, American Wigeon and Bufflehead are early migrants in the area. They are soon followed by Tundra Swan, Scaup spp., Canada Goose and Red-necked Grebe. Late migrants include White-winged Scoter, Surf Scoter, Black Scoter and Red-breasted Merganser.

5.0 DISCUSSION

5.1 Methodological Limitations

Aerial surveys underestimate animal density (Stott and Olson 1972, Caughley 1974, Savard 1982). They are also subject to a number of biases such as observers' identification skills, observer fatigue, angle of prevailing light, ice conditions and albedo, and the skill of the pilot. Although every attempt was made to eliminate or minimize these biases, their presence must be considered when discussing the results.

Table 3. Temporal abundance of migrating species in the Yellowknife-Thor Lake area. Spring 1986.

				May				June
Species	10	14	17	20	23	26	29	02
Common Loon		2	3	6	15	12	2	2
Pacific Loon				2	10	2		
Red-throated Loon					11			
Loon sp.					6			
Red-necked Grebe	6	10	40	12	22	15	16	4
Horned Grebe		3	2	1	8			
Tundra Swan	61	142	584	563	478	345	85	55
Canada Goose	41	41	657	60		1	2	
G.W.fronted Goose			12	140	2	2		
Lesser Snow Goose				10				
Blue-winged Teal						2	27	
Green-winged Teal		15			1		4	
Mallard	83	309	11	44	84	45	37	16
Northern Pintail		346	20	21	17	2	7	
American Wigeon	57	258	21	64	72	48	118	26
Northern Shoveler	2		4	1	4	34	21	
Canvasback		17		40	14			
Scaup sp.	78	443	1040	921	617	307	226	531
Ring-necked Duck		70				7		
Bufflehead	4	159	51	29	33	10	21	20
Common Goldeneye	2	16						
Oldsquaw						11	20	
Duck spp.	700	520	3494	168	88	84	115	219

Table 3. Continued.

Species	May 10	14	17	20	23	26	29	June 02
W.-winged Scoter					5	34	169	13
Surf Scoter			84	10	335	88	38	92
Black Scoter								10
Scoter spp.								34
Common Merganser	6	17			3	8	38	
R.-breasted Merganser		3	12	24	18	38	33	5
Merganser sp.			132	6				12
Golden Eagle								1
Bald Eagle	1	5	1	5	5	16	1	2
Northern Harrier			1	1				
Red-tailed Hawk						1		
Sandhill Crane				4	4			
Caspian Tern								1

The results must also be considered in view of the variability of the survey methods used. Two observers carried out the first survey whereas only one was available for the seven subsequent flights. However, both observers could see only on one side of the Cessna 180, whereas the single observer could see on both sides of the Supercub. Two types of transects were used to survey the 14 selected sites. Only usable waterbird habitat, namely stretches of open water, was surveyed in 13 of the 14 sites. Although constant in length (Appendix 16), these stretches widened as the ice receded, thus adding variability to the observer's capability to locate the birds. At the Thor Lake study site, the 36-km transect line covered 100 square kilometres of both usable and non-usable waterbird habitat, namely land and about 85 waterbodies of all sizes and stages of ice decay. Despite these variabilities, we believe that a fairly representative picture of the spring migration was drawn and that differences between sites were satisfactorily established.

5.2 Abundance of migrating species

The lack of previous studies in the study area limits our perspective when evaluating the observations. In 1985, Arner and Verrault studied the birds of the Bullmoose Lake area, a site close and comparable to the area covered by this study. However, as their objectives and methodology were quite different, no comparison is possible. The two studies complement one another instead of being comparable.

At no time did we attempt to determine the absolute number or the

turnover rate of birds staging in the area. Over 16,000 observations were made throughout the study period. This number must be understood in terms of bird-days rather than the absolute number of birds. However, it provides some insight in the relative abundance of each species.

Observations of particular interest include those of Black Scoters, Bald Eagles, and a Caspian Tern. Black Scoters are rarely observed in the Great Slave Lake region (Godfrey 1986). Their breeding distribution in northern Canada is an enigma. Very few breeding records have been confirmed in the Northwest Territories (Bellrose 1976). Bald Eagles are uncommon in most of North America. However they abound in areas such as British Columbia and Alaska. They are also common around Great Slave Lake. Over 200 nests have been identified in the region (Allen and Ealey 1979). Adult and juvenile Bald Eagles were regularly observed during this study. The Caspian Tern has been classified "Rare" by the Committee on the Status of Endangered Wildlife in Canada. Their population in the Great Slave region is basically unknown but preliminary surveys have identified a substantial number of breeding pairs along the North Arm (McCormick and Sirois, in prep.). This was the first recorded sighting of a Caspian Tern in this part of Great Slave Lake.

5.3 Spatial Distribution.

Migrating waterfowl depend on open water for staging and feeding. Accordingly, concentrations of waterfowl were associated with open water sites. The relative importance of various sites for

waterfowl varied considerably (Fig. 5). The sites with most open water did not necessarily support the most birds (Appendix 16), suggesting that some areas provided better habitat than others. An attempt to rank the sites in terms of bird density (number of birds per km of open water) proved unsuccessful. We believe that sites of truly minor importance were thus rated too high. The "Index of Importance", as defined earlier, appears to rank the 14 sites in a more realistic manner.

Apart from the Slave Delta and the head of the Mackenzie River (Beaver and Mills lakes), which are recognized key migratory bird habitat sites in the NWT (McCormick et al. 1984), little is known about the importance of Great Slave Lake as a migratory staging area. With the exception of the sites mentioned above, no major concentration of migratory birds is known to occur at any particular site. However, this study has revealed that some areas, where open water occurs early in the spring, can support substantial numbers of birds.

Beaulieu River was the most heavily utilized site followed by Devil's Channel and Cabin Islands. Strong currents in both Beaulieu River and Devil's Channel result in open water which appears early and expands rapidly. These sites maintained significant numbers of waterfowl throughout the study period. The Thor Lake site ranked ninth in importance among the 14 sites. Noticeable concentrations at this site included Scaup, White-winged Scoter and Surf Scoter. Few observations of other species were recorded. Flocks of Greater White-fronted Geese and Lesser Snow Geese were observed flying over the Thor Lake area, probably

en route from the Slave River Delta to their Arctic nesting grounds. It is very unlikely that these geese would stage in the vicinity of Thor Lake due to the lack of appropriate habitat.

A relatively low number of birds was seen at the Thor Lake site. Not only does the ice melt later in the vicinity of Thor Lake (Table 1), but the area does not benefit from any noticeable input of nutrients from a river or adjacent Great Slave Lake. Thus it provides less productive and therefore less attractive habitat than nearby sites. However, a relatively high number of species (17) was observed in the vicinity of Thor Lake which compares with the Beaulieu River where a total of 23 species, but ten times as many birds, was observed.

The Yellowknife-Thor Lake area belongs to what has been defined as the Precambrian Edge. The Precambrian Edge is a narrow strip extending along the western edge of the Precambrian Shield from Great Bear Lake to Lake Athabasca. It provides a better-than-average type of northern habitat and has a substantially greater breeding duck density than either the Precambrian open forest to the northeast or the closed forest of the Mackenzie lowlands (Interior Plains) to the southwest. The area has a greater density of ponds than the adjacent portion of the Mackenzie lowlands and is apparently more fertile than the remainder of the Precambrian open forest due to sedimentation and enrichment during post-glacial stages of Great Slave Lake (Murdy 1964).

Although the breeding potential of the Precambrian Edge has been identified in previous studies, its potential as a spring staging

area, apart from the Peace-Athabasca-Slave river system and the head of the Mackenzie River, is poorly known. This study suggests that Great Slave Lake provides significant areas of spring staging habitat.

5.4 Temporal Distribution.

The temporal distribution of the birds observed during the study, and throughout the study area, is compiled in Table 3. Migration patterns and peaks are readily identifiable but the migration phenology is better appreciated in light of the weather information (Fig. 4) and ice conditions (Table 1).

A number of deviations from the long-term mean are apparent when daily temperatures during the 1986 spring break-up are compared to the average of the 1943-1984 period. These deviations are not unusual (G. Burke. AES, pers. comm.). However, the timing of fluctuations, may vary considerably from year to year. During the study period (10 May-02 June), temperatures were higher than usual except for a period of four days (12-16 May). This suggests that south winds, which are conducive to the northward spring migration, prevailed throughout most of the period except for a few days when north winds made temperatures drop significantly below average.

These north winds may have contributed to the migration peak recorded in the Yellowknife area on 17 May by combining a reverse migration and a migratory hold-up (lengthening of the staging period in the area) to the normal northward flow of birds. Over 60% of all the observations recorded during the entire study

coincided with the aftermath of that short cold spell. However, a detailed evaluation of the impact of weather systems on the migration lies beyond the scope of this study. Future field work in the same area and under comparable circumstances would substantiate possible correlations.

No information is available on ice break-up prior to the first survey on 10 May. Open water, on this date, was confined to shallow ponds, bays and sites of running water. The thin ice associated with these sites is obviously conducive to an early break-up. There was relatively little change in ice conditions for the next ten days although there was a progressive expansion of certain shoreleads. These leads, however, were probably influenced by prevailing winds which shifted the lake ice in the direction of their flow.

Significant melt and rapidly changing ice conditions were associated with the 11-day period (17-27 May) when temperatures were well above normal. There was approximately 100% increase in open water during this period. The apparent close association between warm temperatures and ice melt suggests that the timing of break-up can be quite variable from year to year. Important numbers of migrating waterbirds were not seen in the area until 17 May. Then, the highest migration peak was recorded in the Yellowknife area.

Migration peaks varied among species. Many dabblers were early migrants whereas many divers were late migrants. However, the Blue-winged Teal (a dabbler) was a late migrant and the Common

Merganser (a diver) was observed during the first survey. These records are in accordance with the Yellowknife regional checklist (Bromley and Trauger, n.d.). Some migration peaks must be considered in light of the few individuals observed.

6.0 CONCLUSION AND RECOMMENDATIONS

The Precambrian Edge , a better-than-average breeding area for northern waterfowl, also provides attractive spring staging habitat for many migratory bird species. Although concentrations of birds such as those observed in the Slave Delta or at the head of the Mackenzie River were not recorded in the Yellowknife-Thor Lake area, a significant diversity and number of waterbirds were found to use the open water areas along the shore of Great Slave Lake, as the ice receded.

It would appear that the Thor Lake Mine site is not significant, in a regional context, to migrating waterfowl. However, in light of the numbers of Scaup and Scoters, as well as the diversity of birds observed, it is recommended that:

1) spring aerial surveys be conducted for two more years to confirm the temporal and spatial distribution, and relative abundance of species in the study area and on the mine site.
2) ground surveys be conducted on the study site during the breeding season to evaluate breeding populations.

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Appendix 1. Scientific names of bird species observed during the Yellowknife - Thor Lake survey, Spring 1986.

Common Name	Scientific Name	Species Code
Common Loon	Gavia immer	CL
Pacific Loon	Gavia pacifica	PL
Red-throated Loon	Gavia stellata	RL
Unidentified Loon	Gavia sp.	LO
Horned Grebe	Podiceps auritus	HG
Red-necked Grebe	Podiceps grisegena	RG
Tundra Swan	Olor columbianus	TS
Greater white-fronted Goose	Anser albifrons	GG
Lesser Snow Goose	Chen caerulescens	SG
Canada Goose	Branta canadensis	CG
Green-winged Teal	Anas crecca	GT
Mallard	Anas platyrhynchos	MA
Northern Pintail	Anas acuta	NP
Blue-winged Teal	Anas discors	BT
Northern Shoveler	Anas clypeata	NS
American Widgeon	Anas americana	AW
Canvasback	Aythya valisneria	CA
Ring-necked Duck	Aythya collaris	RD
Unidentified Scaup	Athya sp.	SC
Oldsquaw	Clangula hyemalis	OL
Black Scoter	Melanitta nigra	BS
Surf Scoter	Melanitta perspicillata	SS
White-winged Scoter	Melanitta fusca	WS
Unidentified Scoter	Melanitta sp.	S
Bufflehead	Bucephala albeola	BU
Common Goldeneye	Bucephala clangula	GO
Common Merganser	Mergus merganser	CM
Red-breasted Merganser	Mergus serrator	RM
Unidentified Merganser	Mergus sp.	M
Unidentified duck		DU
Bald Eagle	Haliaeetus leucocephalus	BE
Northern Harrier	Circus cyaneus	NH
Red-tailed Hawk	Buteo jamaicensis	RH
Golden Eagle	Aquila chrysaetos	GE
Sandhill Crane	Grus canadensis	CR
Caspian Tern	Sterna caspia	CT

Appendix 2. Abundance of migrating species at Wool Bay. Spring 1986.

Date	Species											
	RG	TS	MA	AW	SC	WS	BU	CM	RM	DU	BE	NH
10 May					15			6		20	1	
14 May												
17 May	8	2	2		85					610	1	1
20 May	1		3		30		4					
23 May			6	3	21	4	4		4			
26 May	3		4		30		2					
29 May	5		1		10		6			8		
02 June					10		2					

Appendix 3. Abundance of migrating species at Site B. Spring 1986.

Date	Species																	
	RL	PL	CL	HG	RG	TS	MA	NP	BT	NS	AW	SC	SS	BU	RM	DU	BE	GE
10 May																350	1	
14 May						2	100	20			22	60		18		90	1	
17 May																		
20 May						29						60		2		56		
23 May	1	2	3	5	1	24	4				2	22	7	2		20		
26 May			1			26			1	1			33	2		27		
29 May						3	1				8	4			5	6		
02 June												6	4	9	2	12		1

Appendix 4. Abundance of migrating species at Jackfish Cove, Spring 1986.

Date	Species												
	CL	HG	RG	TS	CG	MA	NS	AW	SC	BU	CM	RM	DU
10 May													
14 May				2	20					10	2		40
17 May				24					32	12			325
20 May			2	22		6			65	5			
23 May	2	1		32					20	2		2	2
26 May				6		1	12						
29 May				3									
02 June						4		2	20				

Appendix 5. Abundance of migrating species at Moose Bay. Spring 1986.

Date	Species										
	PL	TS	MA	AW	SC	SS	BS	BU	RM	DU	CR
10 May		44	45		22			4		249	
14 May		2		2							
17 May		2	2							14	
20 May		4									2
23 May					2				1	3	
26 May	2				9	10				3	
29 May					6	6				4	
02 June					26		6				

Appendix 6. Abundance of migrating species at Drybones Bay, Spring 1986.

Date	Species																	
	CL	HG	TS	CG	GT	MA	NP	BT	NS	AW	CA	SC	SS	WS	BU	RM	DU	BE
10 May						4												
14 May			14		10	60	5				12	40					70	
17 May		2	35			1	20			3					2		202	
20 May	1		2	15						4		195			2			1
23 May	1									8		31	13				1	
26 May	3		15			4			6	7		10	2	1		2		1
29 May					4	4	1	23	2	5		16					6	
02 June												57					76	1

Appendix 7. Abundance of migrating species at Cabin Islands, Spring 1986.

Date	Species																	
	CL	RG	TS	CG	MA	NP	NS	AW	CA	SC	SS	WS	BU	CM	RM	M	DU	BE
10 May		6	4	4	12			25		20				6				
14 May			31	10	10	65		70	5	20							50	1
17 May			82	15			2	2		12			1			65	155	
20 May			106	15	3			14		50	5							2
23 May	5	1	62		3	2		3		13	30		2				7	
26 May			51				2	7		19					2			1
29 May		3	3		3			4		17		68	2		7		23	
02 June										14						1	42	

Appendix 8. Abundance of migrating species at Matonabee Bay, Spring 1986.

	Species													
Date	TS	GG	CG	GT	MA	NP	BT	NS	AW	SC	WS	RM	DU	BE
10 May	6		35		20				32	6				
14 May	14			5	6	50			15				30	1
17 May	42												150	
20 May	89				12				2	100			45	
23 May	97				6				2	10				
26 May	43	2			12		1	5	4	15	1		4	1
29 May									1			1	5	
02 June	5									2			33	

Appendix 9. Abundance of migrating species at Devil's Channel, Spring 1986.

	Species																
Date	HG	RG	TS	CG	MA	NP	NS	AW	CA	SC	SS	WS	S	BU	RM	M	DU	BE
10 May			7	2	2												65	
14 May	3	3	10	1	1									5			100	
17 May			68	425						19							206	
20 May			50		4			8		26	5			1	3			
23 May	1	4	25		1		2	6	4	10	75			2	2		2	
26 May		1	25		13			5		27	3				11			1
29 May			24	2		2	2	25		37	5	30			2		2	
02 June			18					2		202			20			6	32	1

Appendix 10. Abundance of migrating species at Goulet-Campbell bays, Spring 1986.

Date	Species																					
	RL	PL	HG	RG	TS	CG	MA	NP	NS	AW	CA	SC	SS	WS	BS	BU	CM	RM	M	DU	BE	CT
10 May																						
14 May					37			90		48		4				13				50		
17 May					82	15			2	2		12				1			65	155		
20 May			1	1	40		3	1	1	3		64				5		5		28		
23 May	8	1		6	6		2			7	4	88	21			6	1	4			3	
26 May					22		1			9		30	10	15		2		9		6	2	
29 May				4	14		3	2		26		47	7			8		14		41		
02 June				1			1						25		2							1

Appendix 11. Abundance of migrating species at Site J. Spring 1986.

Date	Species										
	TS	MA	AW	RD	SC	WS	BU	RM	M	DU	RH
10 May										6	
14 May			5				2				
17 May										14	
20 May	2	3	3		10						
23 May		6	2		5						
26 May			4	2	22		2	5		2	1
29 May		3	7		18	25		4			
02 June			4		25				2		

Appendix 12. Abundance of migrating species at Site K, Spring 1986.

Date	Species												
	CL	RG	TS	MA	NP	BT	AW	SC	WS	S	BU	DU	BE
10 May													
14 May				25			5				15		
17 May			2									41	
20 May					2			10				20	1
23 May		2		14			3	3			2		
26 May													
29 May	1			1		2	5	10	5				
02 June		2		8			1	12		14			

Appendix 13. Abundance of migrating species at Francois Bay, Spring 1986.

Date	Species																		
	RL	CL	RG	TS	CG	MA	NP	NS	AW	RD	SC	BS	SS	WS	S	BU	RM	M	DU	GE
10 May																			4	
14 May				10		2	6		13	15	30				18				30	
17 May				69							8								72	
20 May			2	72			3		5		122							6	4	
23 May	2		1	81		3			9		105		17	1					2	
26 May		2	3	22	1	2					12			11		1			18	
29 May				2		8	2	17	18		2			1		2			2	
02 June		2	1	2					12		24	2	37	13	50	2	3	1	20	1

Appendix 14. Abundance of migrating species at Thor Lake, Spring 1986.

	Species																	
Date	LO	RL	PL	CL	RG	GG	SG	MA	AW	SC	OL	SS	WS	BU	RM	DU	BE	CR
10 May																6		
14 May																		
17 May																		
20 May					2	70	10		2	30						4		2
23 May	6	2	4	2					3	106		20		8		36		
26 May				3	3				1	65	11	15		1	2	9	1	
29 May				1	2			2		31	20	11	40			9		
02 June										47		2						

Appendix 15. Abundance of migrating species on Beaulieu River, Spring 1986.

Date	Species																								
	PL	CL	HG	RG	TS	GG	CG	GT	MA	NP	BT	NS	AW	CA	RD	SC	SS	WS	GO	BU	CM	RM	M	DU	BE
10 May														2		15			2						
14 May		2		7	20		10		105	110			78	7	70	289			16	78	15	3		60	1
17 May		3		32	176	12	202		6				14			872	84			35		12	2	1550	1
20 May	2	5		4	147		30		10	15			23	40		159				10		16		11	
23 May	3	2	1	13	151	70		1	39	15		2	24	6		181	152			5	2	5		15	2
26 May		2		5	135				8	2		5	11		5	68	15	6			8	7		15	
29 May				6	36				11		2		19			28	9			3	38			9	1
02 June				1	30				3				5			86	24			7			3	4	

Appendix 16. Relative importance, amount of open water and number of species at each site.

Site	Relative importance*	Amount of open water(km)**	Number of species
Beaulieu River	1	24.0	23
Devil's Channel	2	6.0	16
Cabin Islands	3	7.5	17
Goulet-Campbell bays	4	12.5	20
Francois Bay	5	9.5	18
Site B	6	4.5	17
Matonabee Bay	7	8.0	13
Drybones Bay	8	12.5	17
Thor Lake Study Site	9	36.0***	17
Wool Bay	10	3.0	11
Jackfish Cove	11	3.5	12
Site J	12	4.5	9
Moose Bay	13	3.5	10
Site K	14	4.5	11

* Relative importance determined by "Index of Importance", see Figure 5 and Methods.

** Amount of open water was constant from survey to survey but width increased as ice receded, see Table 1.

*** 36-km survey line above the study site includes open water, ice, and land.